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Use of a novel nesting material by the spider wasp *Dipogon variegatus* (Hymenoptera, Pompilidae)

Sergio Albacete[1,2], Gonzalo Sancho[1,2], Jordi Bosch[2]

1 *Universitat Autònoma de Barcelona, 08193 Bellaterra, Spain* **2** *Centre for Ecological Research and Forestry Applications (CREAF), 08193 Bellaterra, Spain*

Corresponding author: Sergio Albacete (s.albacete@creaf.uab.cat)

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Abstract

A female spider wasp *Dipogon variegatus* was filmed stealing fragments of pollen-nectar provision from a solitary bee (*Osmia cornuta*) nest and using them for the construction of her nest. The female wasp applied the sticky fragments of the pollen-nectar provision to the outer surface of her closing nest plug, thus gluing together pieces of debris filling the nesting cavity. Previous descriptions of *D. variegatus* nests indicate that females of this species usually use spider silk to provide cohesion to the nest plug. Our observations provide an example of behavioural plasticity and innovation in the use of nesting materials. We describe the structure of the nest and the sequence of emergence of the progeny.

Keywords

Behavioural plasticity, nesting biology, *Osmia*, solitary bee

Most bees and wasps in the superfamilies Apoidea, Pompiloidea and Vespoidea are solitary and build nests in which they deposit food provisions for their progeny. Many of these species excavate their nests (usually underground), but some use a variety of pre-established cavities (O'Neill 2001; Danforth et al. 2019). Cavity-nesters typically incorporate external materials such as mud, pebbles, and various sorts of plant matter, including resin, pubescence, leaf cuttings and masticated leaf, to delimit cells and close their nests. The nesting materials used are species-specific. Most species use a single type of material, but some use a combination (Stephen et al. 1969; Iwata 1976). Notably among the latter

are *Dipogon* and other related genera of spider wasps (Pompilidae), which use a combination of materials of mineral, plant, and animal origin (Krombein 1967; Shimizu and Ishikawa 2002). Here we describe a nest of the spider wasp *Dipogon variegatus* (Linnaeus, 1758) and report on the collection and use of a novel nesting material by this species.

In May 2020 we observed a *D. variegatus* female nesting at a nesting station for mason bees (*Osmia* spp.) in Santa Caterina, Parc del Montgrí (Girona, NE Spain). The nesting station contained four nesting wooden blocks. Each block had 25 drilled holes into which paper straws (15 cm long, 8 mm diameter) were inserted. At the time of the observations, several *Osmia cornuta* (Latreille 1805) females were nesting in the wooden blocks. Like other solitary bees, *O. cornuta* stock their nests with provisions of pollen mixed with nectar.

On 5 May, we observed a *D. variegatus* female, entering an active *O. cornuta* nest and coming out with small pieces of provision between her mandibles (https://youtu.be/umbqd9v9n-s). The wasp female then walked to her nesting cavity and applied the stolen piece of provision to the plug of her nest (Fig. 1). This sequence of events was repeated at least 3 times.

On 7 May, the paper straw containing the *D. variegatus* nest was taken to the laboratory and on 17 May we analysed its contents. The spider provisions had completely been consumed and the wasp larvae had already spun their cocoons.

The nest occupied most of the length of the paper tube and had a loose structure, without clearly-defined cell partitions. It contained six cocoons longitudinally or obliquely arranged along the inner third of the paper straw (Fig. 2). The rest of the nest was filled with loose debris, including clumps of soil, pebbles, fragments of leafs and twigs, male pine cones and snail feces. The fragments of *O. cornuta* pollen-nectar provision were only found on the outer surface of the closing plug (Figs 1, 2).

Cocoons were 0.8–1 cm long and 2–3 mm wide and had two distinct layers. The inner layer consisted of a non-translucent whitish matrix with a shiny inner surface. The outer layer was a mesh of silk strands with debris attached to them (Fig. 3). We placed the cocoons individually in small plastic containers and kept them outdoors in a shaded area. Four adults emerged over a period of 4 days (a male from cocoon 5 on the

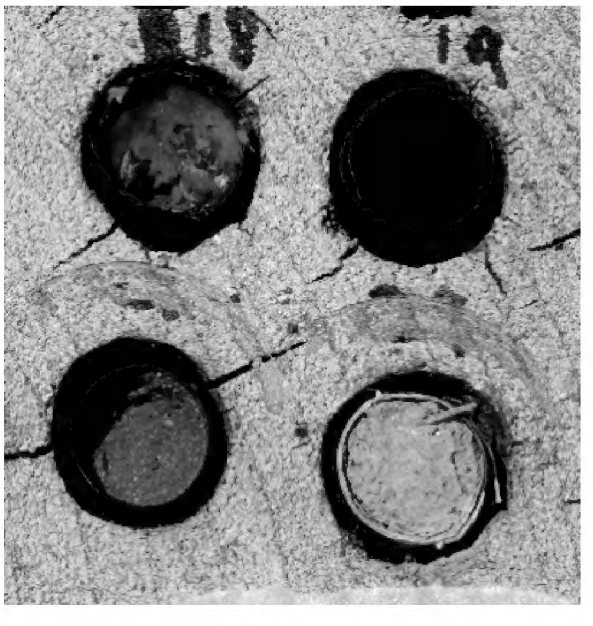

Figure 1. Plug of *Dipogon variegatus* nest (top left) plastered with pieces of orange-coloured pollen-nectar provision stolen from an *Osmia cornuta* nest. The two mud plugs at the bottom are *O. cornuta* nests.

Figure 2. *Dipogon variegatus* nest. The blue arrows indicate the location of the six cocoons, partially hidden by the debris. The red arrow indicates the fragments of the orange-coloured *Osmia cornuta* provision.

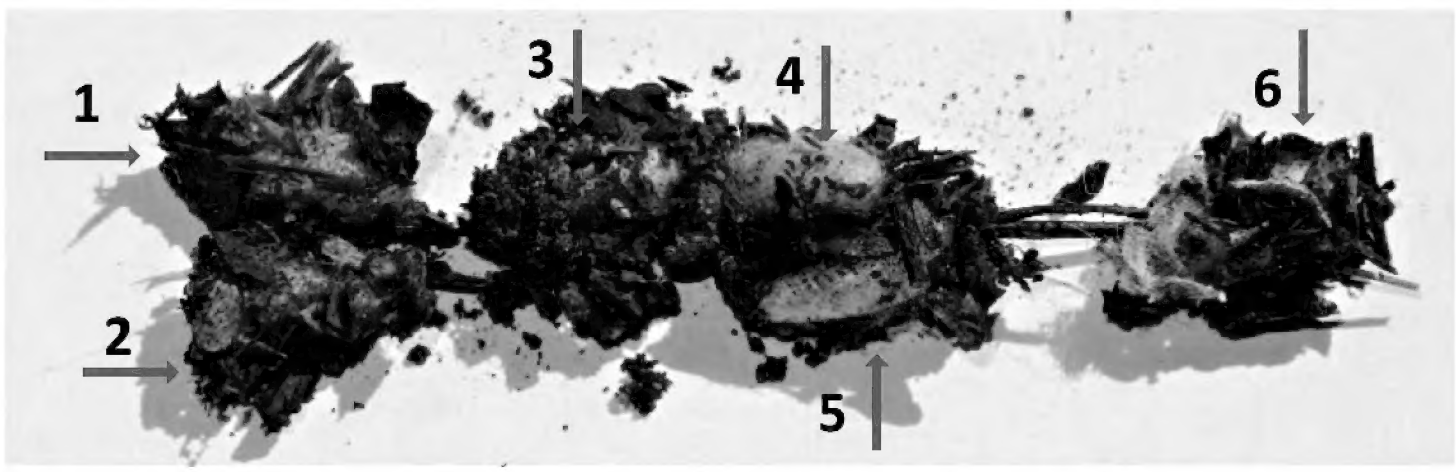

Figure 3. Close-up of the six cocoons after partial removal of the debris.

4th of June, two females from cocoons 1 and 3 on the 6th June, and a male from cocoon 6 on the 7th June). On July 15th we dissected the two remaining cocoons. Cocoon 2 contained a dead prepupa and cocoon 4 a dead male pupa.

Species of *Dipogon* and related genera are known to use a wide variety of materials to build their nests (Krombein 1967), including parts of dead insects and even entire ant corpses (Staab et al. 2014). To our knowledge, however, this is the first report of a solitary wasp using pollen as a nesting material. *D. variegatus* is known to use spider silk to bind together the debris filling its nest, especially at the entrance (Junco and Reyes 1951; Day 1988). The nest we examined had no traces of spider silk. The female we observed used a completely different kind of sticky material, the pollen-nectar provision from a solitary bee nest, to provide cohesion to the various fragments of debris conforming the nest plug. The nesting station created a situation in which a large number of uncapped active solitary bee nests were available in close vicinity of the wasp's nest. This scenario probably facilitated the encounter and use of pollen-nectar provisions by the *D. variegatus* female.

The use of novel nesting materials, sometimes of anthropic origin, has long been documented in birds and has been interpreted as a behavioural innovation in response to a new environmental situation (Hansell 2000). Although not so frequently, this phenomenon has also been reported in solitary wasps and bees. A potter wasp *Symmorphus murarius* (Linnaeus) female was found to cover the external surface of her mud nest plug with flakes of dry paint (Westrich 2020), and various leafcutting bee species, *Megachile* spp., have been reported to use plastic cuttings to line their nests (MacIvor and Moore 2013; Allasino et al. 2019; Wilson et al. 2020; Quintos-Andrade et al. 2021). Our study

provides another example of the capacity of solitary bees and wasps to modify an a priori well-established behaviour whenever the need and/or the opportunity arise.

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